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GB 1596674 A GB 1384020 A GB 1342904 A
US 3816767 A

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(54) Schmitt trigger for DTMF receiver

(57) A Schmitt trigger 10 comprises an NPN transistor T1 and a PNP transistor T2, with T2 supplying positive feedback to the base of T1 through resistor R1. The Schmitt trigger, which has a large hysteresis threshold and which switches rapidly, may be used in a DTMF receiver for remote control of a VCR or a cable box, or in an infrared receiver detector.

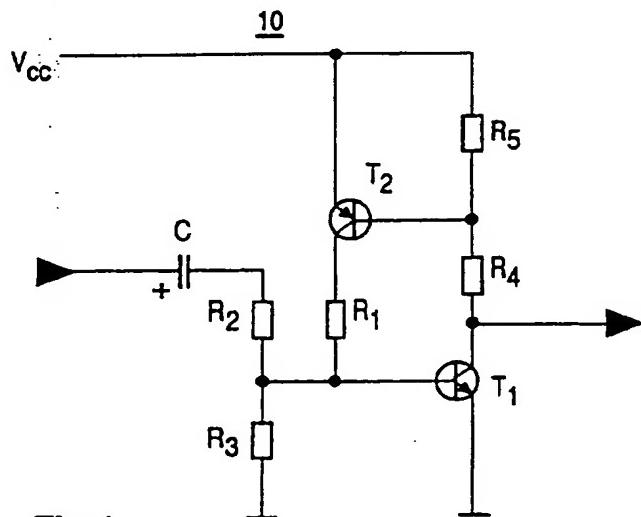
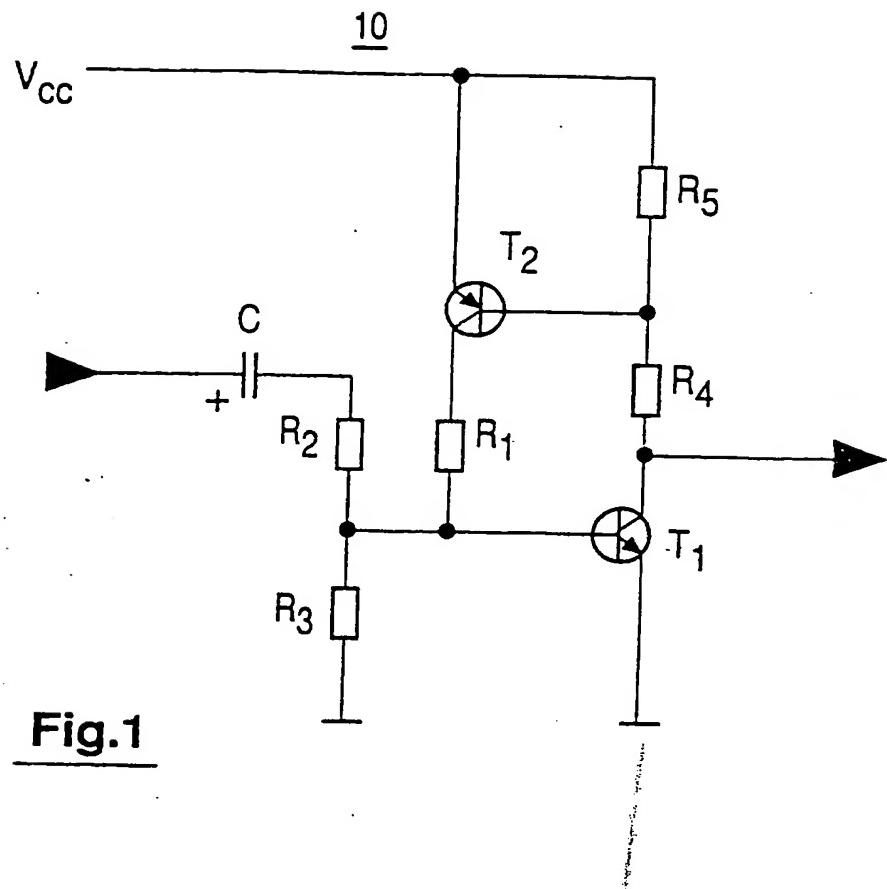
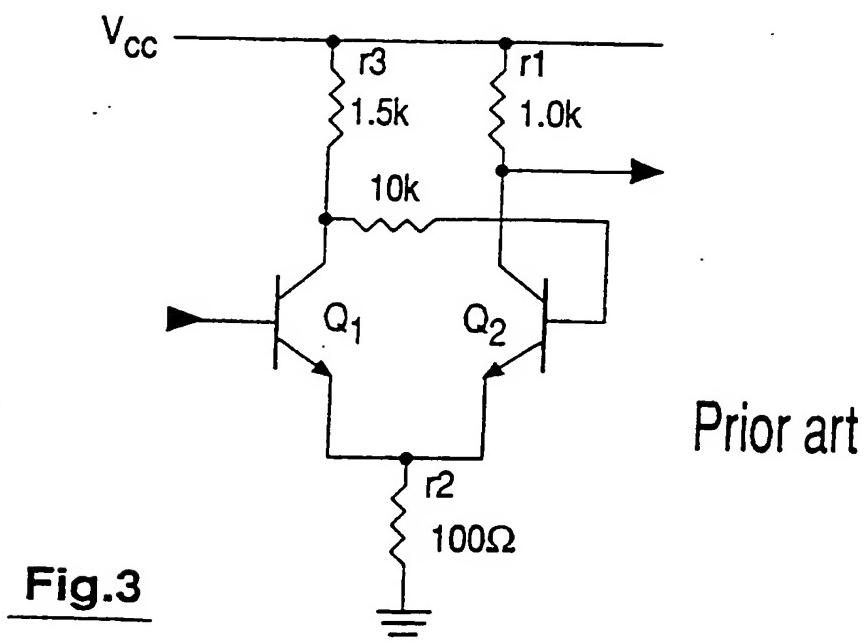


Fig.1

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Fig.1Fig.3

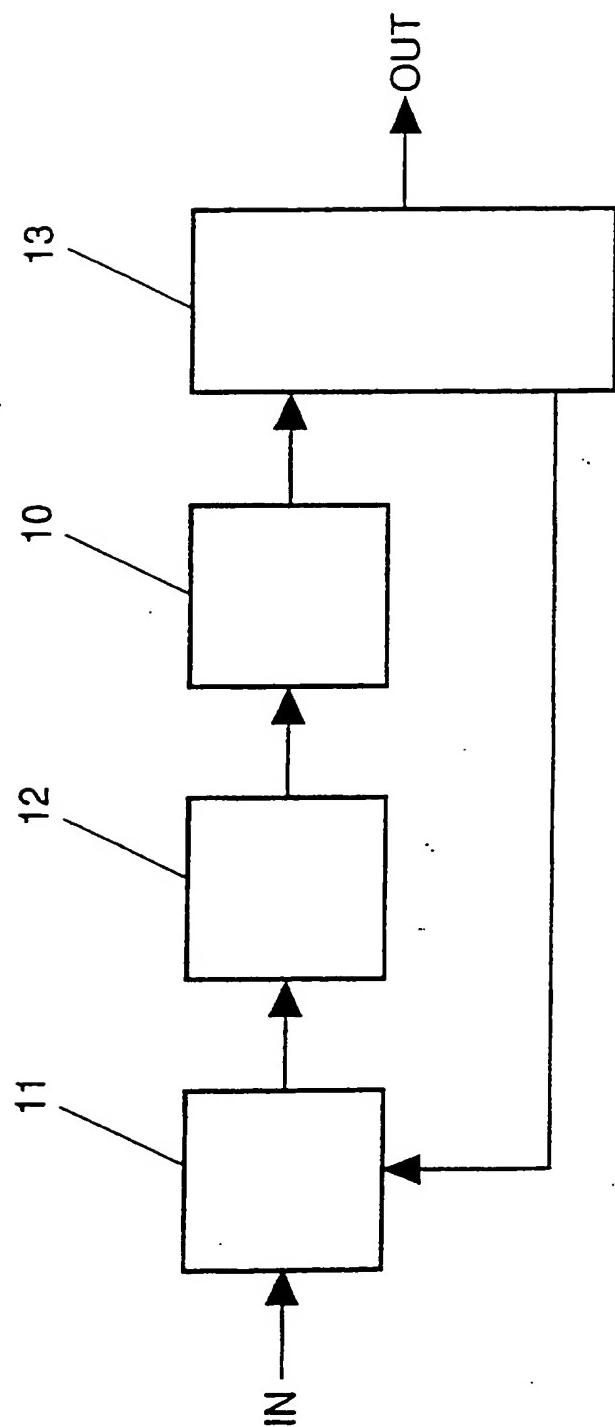


Fig.2

SCHMITT TRIGGER

The invention relates to a Schmitt trigger, in particular to a Schmitt trigger built from two transistors.

Conventionally, a Schmitt trigger is built from an operational amplifier the output of which is positively fed back to the positive input of the operational amplifier. This feed back generates an improved noise immunity and shows a corresponding hysteresis threshold (see Horowitz + Hill: "The Art of Electronics", Cambridge University Press, 1980, p. 126ff). Such a Schmitt trigger configuration uses an integrated circuit and is therefore easy to realize, but high in cost.

Further, Fig. 3 shows a known discrete-transistor Schmitt trigger using two transistors Q₁ and Q₂ (Horowitz + Hill: "The Art of Electronics", Cambridge University Press, 1980, p. 127). Those two transistors Q₁ and Q₂ share a common emitter resistor r₂ and are connected with respective collector resistors r₃ or r₁, respectively, to the power supply line. It is essential that the Q₁ collector resistor is larger than Q₂. In this way the threshold to turn on Q₁, which is one diode drop above the emitter voltage, rises when Q₁ is turned off, since the emitter current is higher with Q₂ conducting. This produces hysteresis in the trigger threshold, just as the above mentioned integrated-circuit Schmitt trigger. The known discrete Schmitt trigger shows the problem, that in its "Off" state the second transistor Q₂ is always conducting which leads to a small but not negligible power consumption. Further, the velocity of the output transition is not sufficient.

It is another disadvantage of the known Schmitt trigger circuits that the hysteresis threshold is small. In fact, it is possible to realise a large hysteresis threshold, which is necessary for certain applications by reducing the ratio of r₁ relative to r₃ and r₂. But in this case the collector output voltage of transistor Q₂ will be increased when it is switched on. This may not be appropriate for logic "low". More stages for level translation become necessary in that case.

It is therefore an object of the invention to provide a low-cost discrete-transistor Schmitt trigger with a fast transition from one state to another with a large hysteresis threshold to compensate for DC offset with AC coupling to non-linear load to improve the noise immunity, said Schmitt trigger having no standby current at logic "high".

This object is solved by the subject matter of independent claim 1.

Further advantages and preferred embodiments are described in the dependent claims.

The Schmitt trigger of the present invention comprises two transistors T_1 , T_2 , wherein the second transistor T_2 is positive fed back to the base of the first transistor T_1 . The feedback of the second transistor of the Schmitt trigger T_2 is accomplished with a resistor R_1 . The input signal of the Schmitt trigger is level shifted with an average DC at zero potential with a voltage divider R_2 , R_3 , wherein normally the input signal of the Schmitt trigger is AC coupled.

To realise a hysteresis threshold larger than in known systems, the ratio of resistor R_1 relative to resistors R_3 and R_2 must be reduced. The collector output voltage of transistor T_2 will be increased when it is switched on.

A Schmitt trigger according to the invention can be used in a DTMF to PWM conversion apparatus, which does a simple conversion of dual-tone-multiple-frequency signals to pulse-width modulated signals.

The Schmitt trigger according to the invention consisting of two transistors configured with a positive feed back realizes a fast transition from one state to the other state with a large hysteresis threshold to compensate for DC offset due to AC coupled signal to a non-linear load and improvement of noise immunity.

The operation of a Schmitt trigger according to the invention is as follows:

When the positive peak of the input signal, which is AC coupled and level shifted with an average DC at zero potential, exceeds the predetermined threshold, V_{on} , the transistor T_1 becomes active. The base voltage of T_2 is pulled low, which causes T_2 to be active, which further causes T_1 to be saturated very quickly. This positive feed back will cause fast saturation of both transistors, so that a fast switching time is realized in a cost effective way.

In a similar way, the positive feedback ensures that both transistors switch off rapidly, when the signal input falls below a predetermined threshold, V_{off} . When T_2 is turned on, the input voltage V_{off} must be lower than V_{on} , wherein the difference is the hysteresis which provides improved immunity against the noise interference.

The "On" and "Off" voltages can be calculated in the following simple way:

$$V_{on} = V_{be} \cdot (R_2 + R_3) / R_3$$

$$V_{off} = \left\{ V_{be} - V_{cc} \cdot \frac{R_2 // R_3}{R_1 + R_2 // R_3} \right\} * \frac{R_2 + R_3 // R_1}{R_3 // R_1}$$

wherein V_{be} : Base-emitter voltage (normally about 0,55V)
 V_{cc} : Supply voltage
 $R_2 // R_3$: means $(R_2 * R_3) / (R_2 + R_3)$
 $R_3 // R_1$: means $(R_3 * R_1) / (R_3 + R_1)$

This results in:

$$V_{off} = V_{be} * \frac{R_1 R_2 + R_2 R_3 + R_1 R_3}{R_1 R_3} - V_{cc} * \frac{R_2}{R_1}$$

This simple and cheap Schmitt trigger can be used in various applications, for example in a DTMF to PWM conversion apparatus, and in an infrared receiver detector, etc. where an improved noise immunity and an adjustment of the detection threshold to compensate for DC offset is needed.

A preferred embodiment of the discrete-transistor Schmitt trigger and its use in an DTMF to PWM conversion apparatus will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 shows a circuit diagram of the Schmitt trigger according to a first embodiment of the invention,

Fig. 2 shows the use of a Schmitt trigger according to fig. 1 in an DTMF to PWM conversion apparatus, and

Fig. 3 shows a known discrete-transistor Schmitt trigger with two transistors.

In the following description of a preferred embodiment values of used components are given in brackets. It may be mentioned that the invention itself is not restricted to these components.

Fig. 1 shows a discrete-transistor Schmitt trigger, with a transistor T₁ (BC 848), the base of which is coupled to a voltage divider consisting of two resistors R₂ (4.7kOhm) and R₃ (4.7kOhm), which normally receive the input signal IN through a capacitor C (4.7uF). The voltage divider R₂, R₃ is grounded like the emitter of the transistor T₁. The collector of the transistor T₁ is positively fed back with a second transistor T₂ (BC 857), i.e. the collector of T₁ is connected to the base of T₂ via a resistor R₄ (43kOhm). Via resistor R₅ (43kOhm) the connection point between the base of T₂ and the collector of T₁ is connected to a supply line V_{CC} (5V), as is the case with the emitter of T₂. Transistor T₁ is of NPN type, whereas transistor T₂ is of PNP type. The collector of T₂ is positively fed back via a resistor R₁ to the base of the first transistor T₁. The output OUT of the Schmitt trigger is formed by the collector of the first transistor. The

functional description of this Schmitt trigger has been already given in the first part of the description, so that it is omitted here. Further the equations for computing the different voltages have already been given.

Fig. 2 shows an embodiment using the Schmitt trigger of fig. 1 in a DTMF to PWM conversion apparatus, wherein DTMF signals are converted into PWM signals. Such an apparatus mainly consists of a switch circuit 11, followed by an amplifier circuit 12 and Schmitt trigger 10, the output of which is fed into a microcontroller 13, which evaluates the TTL signals of the Schmitt trigger 10 as a function of the DTMF frequencies.

The purpose of this apparatus is to program the different channels of, for example, a VCR or a cable box via a telephone line. Therefore in this application an electret-type microphone (not shown) is provided at the input IN of the apparatus, wherein the switch circuit 11, which is controlled by the microcontroller 13, provides power to the microphone for operation. Such an Electret-type microphone is preferred over dynamic-type microphone, as the gain is higher and it is more cost-competetive.

The dual tone frequency signals of the telephone are picked up by the microphone and amplified by the amplifier circuit 12. The Schmitt trigger 10 converts those signals into TTL signals suitable for the microcontroller 13. The output OUT of the microcontroller 13 programs e.g. the cable box following (not shown). With this apparatus the various channels of a TV set, a VCR or a cable box can be programmed from, for example, a remote cable station via a telephone line.

Fig 3 shows a known Schmitt trigger comprising two transistors Q_1 and Q_2 , wherein the base of Q_2 is fed back to the collector of Q_1 via a resistor of 10kOhm. The collector of Q_1 is connected via resistance r_3 (1.5 kOhm) to a supply voltage V_{CC} whereas the collector of Q_2 is connected via a resistance r_1 (1.0 kOhm) to V_{CC} . The emitters of both transistors are coupled via a resistance r_2 (100 Ohm) to ground. The operation of the known Schmitt trigger has been already described in the introductory part of this description.

CLAIMS

1. Schmitt trigger comprising a first transistors (T_1) and a second transistor (T_2), characterized in that the second transistor (T_2) is positive fed back to the base of the first transistor (T_1).
2. Schmitt trigger according to claim 1, characterized in that the type of the second transitor (T_2) is complementary to the one of the first transistor (T_1).
3. Schmitt trigger according to claim 1 or 2, characterized in that the second transistor (T_2) is fed back via a resistor (R_1).
4. Schmitt trigger according to one of the preceding claims, characterized in that the input signal is level shifted with an average DC at zero potential with a voltage divider (R_2 , R_3).
5. Schmitt trigger according to claim 4, characterized in that the voltages are calculated as follows:

$$V_{on} = V_{be} \cdot (R_2 + R_3) / R_3$$

$$V_{off} = V_{be} * \frac{R_1 R_2 + R_2 R_3 + R_1 R_3}{R_1 R_3} - V_{cc} * \frac{R_2}{R_1}$$

6. Schmitt trigger according to anyone of the preceding claims, characterized in that the input signal is AC coupled.
7. DTMF to PWM conversion apparatus comprising a Schmitt trigger (3) according to claim 1 to 6.
8. DTMF to PWM conversion apparatus according to claim 7, characterized in that the apparatus further comprises a switch circuit (11), followed by an amplifier circuit (12) and a microcontroller (13), which also controls said switch circuit (11) wherein the Schmitt trigger (10) is located between the amplifier circuit (12) and the microcontroller (13).

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

-7-

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Relevant Technical Fields		Search Examiner MR K SYLVAN
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(ii) Int Cl (Ed.6)	H03K (3/2893, 3/2897) H04Q (1/453, 1/457)	Date of completion of Search 7 DECEMBER 1995
Databases (see below)		Documents considered relevant following a search in respect of Claims :-
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.		1-8
(ii)		

Categories of documents

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A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1596674	(SIEMENS) see the Figure	1-4
X	GB 1384020	(BENDIX) see transistors 40 and 36 in Figure 3	1, 2, 4
X	GB 1342904	(PLESSEY) see T10 and T12 in Figure 3	1-4
X	US 3816767	(ELECTROSPACE) see the Figures	1-4, 6

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